Large-scale land acquisitions in global agricultural supply chains: Assessing the challenges for human rights and environmental due diligence laws

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Abstract: *The study highlights the specific human rights and deforestation risks related to large-scale land acquisitions (LSLA) in three major global agricultural supply chains – palm oil, rubber, and sugarcane. Our data show that in all three supply chains, LSLAs in low- and middle-income countries play a key role in global production. While deforestation risks from LSLAs are limited in the sugarcane sector, there is a high risk of deforestation in the palm oil sector, particularly in Indonesia, where LSLAs have often taken place in previously abundant tropical forests. Human rights violations associated with LSLAs range from lack of consent from local communities to the displacement of communities, while the associated labour-intensive production models often lead to labour rights abuses. Emerging human rights and environmental due diligence (HREDD) laws could hold companies accountable for adverse impacts that are related to the practice of LSLAs. This paper highlights three major challenges to that: First, the lack of traceability in the reviewed supply chains poses a significant challenge, with variations between sectors in terms of already established traceability mechanisms and the complexity of the supply chains. In terms of traceability, rubber supply chains are especially problematic due to high levels of fragmentation. Second, the emerging importance of Asian countries as major import markets provides producers the option to incorporate inconspicuous LSLAs into supply chains serving Western markets, while high-risk LSLAs could potentially serve South–South trade or domestic markets. Third, in markets regulated by HREDD, LSLAs and their affiliated production systems might have a comparative advantage over smallholder farmers. The study underlines in particular the need for specific and effective due diligence laws that addresses human rights risks of LSLAs that are driven by weak land governance systems in producer countries.*

Keywords: sustainable supply chains; traceability; palm oil; rubber; sugarcane; large-scale land acquisitions

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1 Introduction

Large-scale land acquisitions (LSLA) in low- and middle-income countries by international investors play a major role in the production of key agricultural commodities for global markets. To date, the Land Matrix Initiative's database has observed 2,048 concluded land deals,[1] amounting to over 36 million hectares globally (Land Matrix, 2022).[2] Within the public discourse, the phenomenon is commonly labelled "land grabbing," owing to its extensively debated adverse outcomes. These include violations of customary land tenure rights in targeted countries (FAOSTAT, 2023; Montilla Fernández, 2017) and adverse environmental effects such as deforestation, soil degradation, and water stress that threaten the remaining natural ecosystems and global biodiversity (Davis et al., 2023; Lay et al., 2021). In addition, the labour-intensive production models typically adopted following LSLAs are susceptible to labour abuses, especially in regions where the labour supply is constrained (Bureau of International Labor Affairs, 2022).

Efforts aimed at defining and addressing environmental and social responsibility in LSLAs have primarily concentrated on the role of investors (Flachsbarth et al., 2020). While international investors are relevant stakeholders in this process, little attention has been paid to the fact that the production of agricultural goods on the acquired land is usually part of global supply chains. When looking at LSLAs from this perspective, the focus shifts from the investors to the buyers of the agricultural commodities in often distant markets, and other involved actors along the complex global supply chains.

Palm oil, sugarcane, and rubber are three prominent examples of LSLA-related products that are integral to global supply chains and used as inputs for a plethora of food and non-food commodities, including biofuels. Transnational LSLAs in the oil palm sector that were recorded in the Land Matrix database add up to more than 6.5 million hectares under contract. If fully planted, this would account for almost one quarter of the total global oil palm area. Area under contract of LSLA for sugarcane production amount to two million hectares. If fully planted, this would account for about 8 per cent of the global sugarcane area (FAOSTAT, 2023; Land Matrix, 2022). Rubber concessions are highly concentrated in Southeast Asia, but are increasingly also found in Africa, the area under contract amounting to 14 per cent of the global production area. These figures illustrate that LSLAs are not a fringe phenomenon in the production of key agricultural commodities; rather, they hold significant relevance and must be taken into account to achieve sustainable supply chains. This holds especially true for core global agricultural commodities such as palm oil, sugarcane, or rubber, whose production

[1] We downloaded the Land Matrix data on 28 March 2022; all figures presented in this report refer to Land Matrix data from this date.

[2] These transactions are defined by the existence of a concluded contract to acquire more than 200 hectares of land through purchase, lease, or concession in a low-income or middle-income country for agricultural purposes by a foreign actor between 2000 and 2022.

is mainly located in biodiversity hotspots that harbour most of the remaining tropical rainforests, such as Indonesia, Laos, and Brazil. Safeguarding these tropical forests is of great importance in global action against climate change. Apart from deforestation risks, there is ample evidence of human rights violations associated with LSLAs such as the lack of free, prior, and informed consent (FPIC) of affected communities, along with conflicts associated with the lack of recognition of customary land rights (Lay et al., 2021). However, the labour-intensive production models that often follow LSLAs also lead to severe human rights violations, such as forced or child labour (Bureau of International Labor Affairs, 2022). Since LSLAs are also on the rise in other tropical world regions – such as oil palm plantations in Papua New Guinea, Congo, and Liberia and sugarcane plantations in Cambodia, Zambia, and Mali – understanding the risk patterns and finding ways to hold supply chain actors accountable matters globally. Many of these target countries show patterns of insecure land tenure and a lack of functioning institutions (Meijaard & Sheil, 2019), which makes responsible practices by downstream actors even more important.

The international policy arena long ago recognised the link between land-based risks at the production level and downstream production and consumption in distant markets. Global frameworks outlining the responsibilities of governments and business enterprises, to prevent, address, and remedy the impacts of globalised business activity on human rights include the United Nations Guiding Principles on Business and Human Rights (UNGPs), the Voluntary Guidelines on the Responsible Governance of Tenure (VGGT), and the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI). Alongside international efforts, private governance via voluntary sustainability standards has gained increasing importance over the past few decades (Flachsbarth et al., 2020; Halabi & Lin, 2017; Swinnen, 2016).

Yet, despite the array of multilateral declarations and private-sector initiatives, few sustainable and responsible land-based agricultural investments have been implemented on the ground, and transparency initiatives, such as the Land Matrix or OpenLandContracts, show that most deals remain opaque (Flachsbarth et al., 2020; Lay et al., 2021). As a public response to mounting evidence of the limitations of voluntary measures, new supply chain regulations in countries located in the Global North are on the rise (European Coalition for Corporate Justice, 2019; Schilling-Vacaflor & Lenschow, 2021; Zamfir, 2020). In Europe, the adoption of a range of mandatory due diligence legislation with the declared objective of holding companies accountable for environmental and human rights impacts along their supply chains is in process. Mandatory human rights and environmental due diligence (HREDD) regulations have been created at the national level including the French Duty of Vigilance Law, the German Supply Chain Act, and the Dutch Child Labour Due Diligence Law. At the EU level, a new law for a regulation on deforestation-free products that came into force in mid-2023 and the EU's Corporate Sustainability Due Diligence Directive (CSDDD) was approved the EU Council in early 2024.

With the increasing prevalence of HREDD, we investigate their role in addressing human rights and environmental risks associated with LSLAs. It is, for example, often unclear if the sourced physical commodities can be actually traced through complex global supply chains back to specific high-risk LSLAs. Furthermore, mandatory HREDD will impact the organisation of agricultural supply chains. Downstream actors may adjust sourcing strategies to ensure compliance or avoid consequences of non-compliance. This could involve companies completely avoiding purchases in high-risk regions or excluding smallholder farmers, potentially exacerbating vertical integration through LSLAs with known adverse effects on local livelihoods. Moreover, for some commodities, the overall impact of HREDD may be limited if import markets for conventional produce are sufficiently large. We focus on the following topics:

1. How relevant are LSLAs in terms of area, production, and export shares for product-specific global agricultural supply chains?
2. How frequent are land-related human rights violations, and what are the environmental risks that can be attributed to LSLAs embedded in global supply chains?
3. What are the major challenges for human rights and environmental due diligence law to address LSLA-specific supply chain risks?

The rest of the study is organised as follows: Section 2 gives an overview of the global LSLA-specific supply chain risks. Sections 3 and 4 analyse the environmental and human rights risks in specific value chains. Current challenges for HREDD with respect to LSLA-specific risks are discussed in Section 5. Section 6 concludes the study.

2 An overview of the global risks of LSLAs within global supply chains

Transnational LSLAs are a global phenomenon and affect various geographic regions as well as agricultural subsectors. For a few agricultural commodities, LSLAs are also an integral part of global supply chains given their total and relative size. Some of these LSLAs that are part of global supply chains involve high social and environmental risks related to their aforementioned size but also due to the specific regulatory conditions in the target countries. This section discusses in detail specific crops which are relevant in three ways: (1) LSLAs play a crucial role in their global production and supply chains, (2) their target countries are mainly in the Global South, and (3) they pose high risks of land-based human rights violations and/or deforestation.

Table 1 lists the 10 most important crops based on their global area under production from LSLAs.[3] The most important crop produced on LSLAs in terms of the three criteria above is oil palm, followed by sugarcane and rubber. With 6.5 million hectares, oil palm has the largest LSLA-area under contract of all crops worldwide, of which between 1.9 and 3.5 million hectares are operational. Therefore, the oil palm production area from LSLAs comprises between 7 to 13 per cent of the total global area harvested. Oil palm production is related to high environmental and human rights risks. Suitable land for oil palm cultivation overlaps with tropical rainforest areas – which comes with high deforestation risks.[4,5] Further, data show a substantial percentage of oil palm deals that involve conflict over land, a rejection of the investment by local communities, and/or the displacement of people (Lay et al., 2021).

Sugarcane and rubber have a lower absolute size and relative relevance than oil palm in global supply chains (Table 1). Nevertheless, their extensive production is concentrated in a few tropical regions. Specifically, Brazil is a key region for sugarcane cultivation, while Cambodia is a significant contributor to the rubber sector. Both regions are susceptible to risks associated with deforestation and land-based human rights violations. However, compared to oil palm, deforestation risks are substantially lower. In Brazil, sugarcane cultivation is predominantly situated in the south-central and to some extent in the northeastern region, outside the tropical rainforest areas (Zheng et al., 2022). Aside from that, sugarcane production has stagnated over the course of the last decade (FAOSTAT, 2023), causing only limited pressure on forests. In the case of rubber, the lower rates of direct deforestation can be partially attributed to the fact that the total area under LSLAs for rubber is considerably smaller compared to oil palm concessions. Another reason is, however, that Laos – the main target region for

[3] The lower bound of area under operation equals the area size where the Land Matrix database has recorded the specific operational area size of land deals. The upper bound of area under operation equals the total deal size when the operational area size is missing but the deal is known to be operational. The contract area size exceeds the area under operation since it also includes deals in the start-up or preparation phase.

[4] The LSLA-specific deforestation risk is calculated by taking the total crop-specific deforestation risk of the trade year 2018 per country – which is taken from CommodityFootprints.earth (2023) platform – and multiplying it by the LSLA-area share of total area harvested of the specific crop per country. The dataset contains estimates of tropical deforestation involved in the production, exports, imports, and consumption of agricultural and forestry commodities by country, year, and commodity. The method is based on Pendrill et al. (2019) using a land-balance model to attribute deforestation across 135 countries/territories in the tropics and subtropics to expansion of cropland, pastures, and forest plantation and the commodities produced on this land. For further methodological details, see Croft et al. (2022).

[5] Based on the CommodityFootprints.earth (2023) database and LSLA contract area, we estimate total oil palm–related deforestation risk area to be up to 215,000 hectares in 2018 for LSLA contract area, of which 64,000 to 128,000 hectares belong to LSLAs currently in production. CommodityFootprints.earth (2023) makes some simplified assumptions: they assume yearly deforestation risks distribute equally across crops and their production expansion per year, as well as across production systems (i.e. smallholder production, large-scale production) per crop in each country. Therefore, the given numbers are likely even an underestimation of the true deforestation risk. According to Trase (2023) – which takes a more granular approach to measuring deforestation patterns – Indonesian deforestation risks due to oil palm production were more than double the size estimated by the CommodityFootprints.earth platform. We refer to the numbers provided by CommodityFootprints.earth in this context to make data comparable to relevant products not covered by Trase (2023).

rubber by transnational investors – is excluded in the global deforestation statistics in the CommodityFootprints.earth (2023) database due to missing information, which downward biases the results.[6]

While the absolute sizes of LSLAs for the other seven crops presented in Table 1 are high, their significance in global supply chains is comparatively low when contrasted with other production systems. This holds true for maize, cotton, sunflower, wheat, and cocoa. Global cocoa production, for example, is strongly dominated by smallholder farmers. Additionally, the remaining crops (barley, sugar beet, sunflower, and wheat) often involve acquisitions of agricultural land located in temperate climate zones such as Russia and Ukraine and often take place on land already designated for commercial use, thereby lacking the deforestation risks of tropical crops. Given these considerations, we exclude these seven crops from further discussion. However, it is important to acknowledge that they, too, carry risks for human rights violations, and these should be recognised in supply chain regulations.

We select countries with clusters of LSLAs for our analysis of environmental and human rights risks. For oil palm, Indonesia is globally the most important producer country. In 2018 Indonesia accounted for approximately 60 per cent of the world's production of 410,853,537 tonnes of oil palm fresh fruit bunches (FFB) (FAOSTAT, 2023). With an LSLA share between 9 and 19 per cent of FFB produced compared to other production systems, such as domestic plantations or smallholder farms, transnational LSLAs in Indonesia are essential to meet global palm oil demand. If we assume that a large proportion of processed LSLA produce is destined for export markets, up to almost 30 per cent of Indonesian palm oil exports and up to almost 50 per cent of palm kernel oil exports may originate from plantations owned by foreign investors.[7]

As with palm oil, natural rubber production is clustered in Southeast Asia. In 2018 Indonesia and Thailand alone produced half of the 14,234,107 tonnes of global rubber (FAOSTAT, 2023). However, in contrast to palm oil, natural rubber is produced to a large extent by small-scale farmers in these

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[6] Data collected by Global Forest Watch (2023) show that there is a clear link between commercial agriculture and deforestation in Laos. Global Forest Watch (2023) states that 295,000 hectares of natural forest were converted into commercial land uses in 2018, of which 200,000 hectares were commodity-driven deforestation. According to the literature, a significant part of this high deforestation rate can be attributed to large-scale rubber cultivation in southern Laos (Junquera et al., 2020; Lay et al., 2021; Warren-Thomas et al., 2018).

[7] Palm oil and palm kernel oil are extracted from different parts of the oil palm fruit. Palm oil is traditionally used for edible purposes such as cooking and as an ingredient for processed food. Palm kernel oil is generally used for non-edible purposes such as the formulations of soaps, cosmetics, and detergents – oleochemicals – due to its higher saturated fat content (Gibon, 2012). The reason for the higher LSLA share in palm kernel oil exports is due to the lower overall export share of palm kernel oil, with only 40% of the total Indonesian production being exported, compared to an export share of almost 70% of total Indonesian palm oil production. Note that the stated figures of the share of exports originating from LSLA estates are estimates and should be interpreted with caution.

countries. Over the past two decades, transnational investors have primarily focused on acquiring land for rubber production in other tropical countries such as Laos, Cambodia, Côte d'Ivoire, and Cameroon (Land Matrix, 2022), while rubber concessions in Indonesia date back to before the year 2000. This is also reflected in the country-level cultivation area: while the global rubber cultivation area increased by 64 per cent from 2000 to 2018, Laos recorded an increase of 150 per cent, and Cambodia and Côte d'Ivoire witnessed a surge of nearly 500 per cent during the same period (FAOSTAT, 2023). Despite being relatively smaller global production regions, we hence select Cambodia and Côte d'Ivoire for further analysis, as both countries have emerged as hotspots for LSLAs in the rubber sector.[8]

The main producer country of sugarcane is Brazil. With 747,556,774 tonnes of sugarcane in 2018, Brazil is the single most important producer market globally, producing almost 40 per cent of total global production. Other important sugar producer markets are India with 20 per cent, followed by Thailand with 7 per cent of global production (FAOSTAT, 2023). India and Thailand, however, do not play a major role when it comes to sugarcane LSLAs; according to data from the Land Matrix (2022), more than two-thirds of global sugarcane LSLAs are located in Brazil. Within Brazil, LSLA land makes up about 10 per cent of the total land allocated to sugarcane production in the country, which is why selected Brazil for a more in-depth analysis.

[8] In Cambodia, there is more uncertainty about how much LSLA land is operational, but at least 15% of the rubber producers are controlled by large-scale investors.

Table 1. Overview of commodity-specific relevance of LSLAs for global agricultural value chains with associated supply chain risks in producer countries

Crops	Global LSLA contract area ('000 ha)	LSLA area under operation ('000 ha, lower and upper bound)	Share of operational LSLA of global crop area (%, lower and upper bound)	Main LSLA regions: Countries' LSLA areas share per crop (%, lower and upper bound)	LSLA-related deforestation risk ('000 ha, lower and upper bound)	Human rights violations reported for land deals (%, share of deals)		
						Displacement of local people	Rejection or mixed reactions to investment	Conflicts over land
Barley	4,401	2,214 – 3,991	4.6 – 8.3	UKR (42 – 46), RUS (41 – 46)	0.1 – 0.1	1.3	4.6	8.6
Oil palm	6,536	1,871 – 3,507	6.7 – 12.6	IDN (66 – 78), PNG (5 – 6)	64.3 – 128.4	6.6	22.0	22.4
Maize	4,055	1,561 – 2,867	0.8 – 1.5	BRA (17 – 32), UKR (20 – 35), RUS (14 – 15)	4.7 – 5.1	6.6	9.7	5.1
Sugarcane	2,001	1,239 – 1,517	4.7 – 5.7	BRA (67 – 82), UGA (0 – 3), KHM (0 – 3)	2.1 – 2.2	14.6	29.3	11.0
Cotton	807	457 – 693	1.4 – 2.1	BRA (55 – 83), ARG (6 – 9)	5.5 – 5.5	0.0	10.9	10.9
Rubber	1,753	362 – 568	3.0 – 4.6	LAO (23 – 25), KHM (8 – 22), CIV (9 – 14)	2.1 – 5.8 (w/o LAO)	7.0	28.7	20.9
Sugar beet	547	32 – 531	0.7 – 11.1	RUS (91 – 100)	0	0.0	0.0	7.1
Sunflower	450	96 – 412	0.4 – 1.5	RUS (55 – 63), UKR (22 – 40)	0	0.0	0.0	0.0
Wheat	414	36 – 353	0.02 – 0.2	RUS (45 – 91), UKR (0 – 54)	0	0.0	13.6	4.6
Cocoa	697	16 – 318	0.1 – 2.8	COD (6 – 78), PNG (14 – 93)	0.1 – 1.1	0.0	26.3	15.8

Source: Authors' calculations based on Land Matrix (2022), FAOSTAT (2023) *and the* CommodityFootprints.earth (2023) *database.*
Notes: The 10 crops listed make up more than 70% of total global LSLA area in operation.
The size information is the aggregate of contract size or size in operation per deal, respectively, divided by the total number of crops per deal.
Interpretation of the LSLA-specific HR violations reported by the Land Matrix should be treated with caution, because the majority of deals show missing information. Therefore, these human rights risks depict a lower bound, because for at least these deals human rights violations were present.
The deforestation exposure is calculated by taking the total consumption-based deforestation exposure per producing country for the harvest and export year 2018 (based on the data taken from the CommodityFootprints.earth (2023) *platform and multiplying it by the LSLA-area share of total area harvested per country). Rubber deforestation estimates are underestimated since only natural rubber in its primary form is considered.*

3 Environmental risks from LSLAs in global supply chains

LSLAs are associated with a multitude of environmental risks such as overuse of water resources or contamination through improper use of chemical inputs. Land Matrix data show that LSLAs often lead to input-intensive cropping systems that demand in particular significant water resources, even in arid regions. The Land Matrix data show that 54 per cent of all deals aim to cultivate water-intensive crops such as cotton, oil palm, rubber, and sugarcane (Lay et al., 2021). The intensive use of water for LSLAs could pose severe environmental risks for entire regions due to significant changes in the hydrological cycle (Johansson et al., 2016). In addition, the intensified use of fertilisers and pesticides associated with LSLAs and their subsequent production systems could also pose environmental and health risks, even though little systematic evidence is available across regions (Negatu et al., 2016). However, these risks typically stem not from the land acquisition itself, but rather from the subsequent adoption of input-intensive production models commonly associated with large-scale acquisitions. Deforestation, however, is one of the most visible and often direct environmental consequences of the practice of LSLAs. The following sections focus hence on deforestation risk related to rubber and palm oil using the examples of Indonesia and Cambodia, which are, as shown in the previous section, some of the most important countries with regards to global production and LSLAs in their respective sectors. Even though all three reviewed products – palm oil, rubber, and sugarcane – are grown in (sub-)tropical regions, palm oil and rubber production carry much higher deforestation risks than Brazilian sugarcane production. Sugarcane replaced mainly pasture land, and only 0.5 per cent of the sugarcane production area replaced savannah or forest (Follador et al., 2021); hence, for sugarcane, we focus only on human rights violations (see Section 4).[9]

3.1 Evidence from oil palm LSLAs in Indonesia

Oil palms grow in tropical climate and, unlike many other crops, can be cultivated on a wide range of tropical soils (Pirker et al., 2016). Table 1 illustrates that global palm oil deals are associated with high rates of deforestation. Figure 1 shows that Indonesian palm oil production is one of the world's biggest contributors of tropical deforestation-related environmental risks. Leveraging data from CommodityFootprints.earth, a database reporting estimates of global environmental impacts and risks arising from agricultural consumption and production, we have aggregated the cumulative tropical deforestation risks associated with global agricultural production. For 2018 the database shows that total global agriculture-related deforestation risk was at more than five million hectares

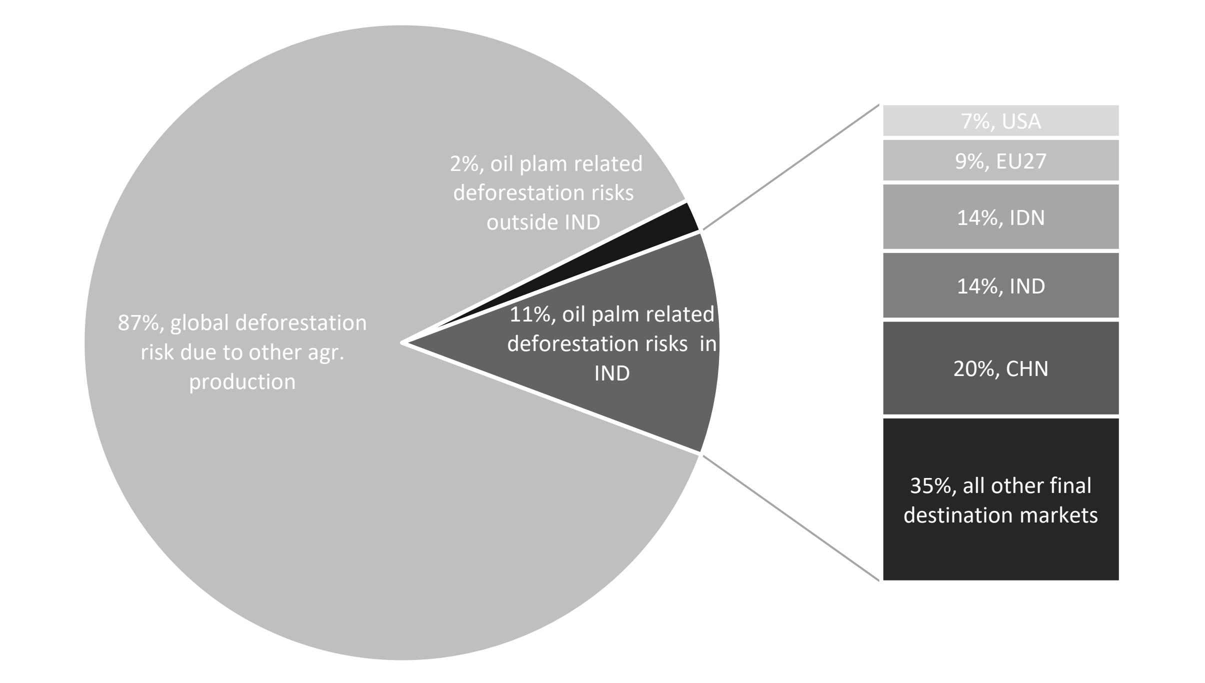
[9] Cultivating degraded pasture requires an elevated use of fertiliser and limestone to achieve desirable degrees of sugarcane productivity, which does lead to additional greenhouse gas emissions from sugarcane production. In addition, despite national efforts, some northern regions of Brazil still rely on burning sugarcane straw to facilitate manual harvesting, which further contributes to greenhouse gas emissions. This practice, however, does not play a major role on highly mechanised LSLA farms (Follador et al., 2021).

(CommodityFootprints.earth, 2023). Other recent studies give an estimate between 6.4 and 8.8 million hectares of agriculture-related deforestation per year between 2011 and 2015. While there is uncertainty regarding the absolute numbers, all sources agree that palm oil is one of the core risk commodities (Pendrill et al., 2022). Data from CommodityFootprints.earth show that the exclusive contribution of Indonesian oil palm production alone accounts for 11 per cent of the total global tropical deforestation risks attributed to agriculture. If we consider only the 19 per cent LSLA production share in Indonesia, LSLAs for palm oil in Indonesia contribute to just over 2 per cent of total agricultural production-related tropical deforestation globally.[10]

From a supply chain perspective, it is important to understand how the environmental risks distribute across the core destination markets. To disaggregate the risks by consumer country, we refer to CommodityFootprints.earth (2023) and a methodology developed by the Stockholm Environmental Institute (SEI). SEI prepares the data by its Input-Output Trade Analysis (IOTA) framework, which uses physical production and trade information from the UN Food and Agriculture Organization and a multi-regional input-output model of the global economy from EXIOBASE. The deforestation risk for each consuming region is then calculated as described in the footnote of the previous paragraph. Figure 1 shows that a large proportion of the environmental risks associated with the consumption of end products containing Indonesian palm oil can be associated with a few regions or countries, starting with China, India, Indonesia itself, the European Union, and the USA. While the EU's market share of Indonesian oil palm exports was at 13 per cent in 2018 (FAOSTAT, 2023), its consumption share was 9 per cent due to exports of the processed products to other world regions. This shows that trade flows alone are insufficient in measuring supply chain risks from farm to fork. This also means that in addition to European retailers, European manufacturing companies play an important role in shifting global supply chains toward sustainable practices. But it also becomes clear that other global players (China, India, Indonesia, and the USA) must be included for effective global sustainability efforts (Heilmayr & Benedict, 2022). The success of a sustainable transformation of oil palm production hinges significantly on the consumption preferences of non-European countries, a particularly important factor being Indonesia's willingness to adopt European sustainability initiatives.

[10] In terms of absolute numbers, CommodityFootprints.earth (2023) reports 610,000 hectares of oil palm-related deforestation risk in Indonesia in 2018.

Figure 1. Distribution of global deforestation risks due to agricultural production (left) and distribution of deforestation risks of Indonesian oil palm production by consumer country (right)



Source: Authors' calculations based on CommodityFootprints.earth (2023).

3.2 Evidence from rubber LSLAs in Cambodia

Current evidence suggests that global rubber production is associated with considerable deforestation. Inkonkoy (2021) reports that over five million hectares of tropical forest were cleared for rubber plantations in Southeast Asia and sub-Saharan Africa between 2003 and 2017, and an additional 4.3 to 8.5 million hectares of land will likely be required to meet the projected growing global demand by 2024. However, due to limited data on rubber production in key production countries such as Laos and Côte d'Ivoire, we concentrate our discussion on deforestation risks using the available data from Cambodia.

Figure 2 illustrates that Cambodian rubber production for global supply chains entails deforestation risk, albeit at a much lower absolute level than that of Indonesian palm oil. Over the past decade, CommodityFootprints.earth (2023) has reported an absolute increase in deforestation-related risks from about 1,000 to almost 4,000 hectares per year associated with natural rubber production in its primary form in Cambodia alone.[11] This is likely an underestimation since processed rubber products are not included. This figure is also small compared to the size of rubber plantations established on former forest land, which includes new plantations on land that was deforested several years or even

[11] The yearly deforestation risks are taken from the same data source (CommodityFootprints.earth, 2023) that we used to calculate the allocation of palm oil-related deforestation risks (see Table 2 above). This means that the given deforested hectares per year assume a three-year time lag, which accounts for deforestation having taken place three years before initial harvests. Furthermore, total deforestation per crop is distributed over the past five years.

decades prior to the planting of rubber trees. Hurni and Fox (2018) show that total deforestation related to rubber production could reach almost three million hectares in Cambodia between 2001 and 2014. Other studies estimate that, between 2010 and 2015, 20,000 to 100,000 hectares of forest in Cambodia were converted to rubber annually (Grogan et al., 2018; Warren-Thomas et al., 2023). While all studies establish a clear connection between rubber and deforestation, absolute deforestation numbers should be interpreted with caution.

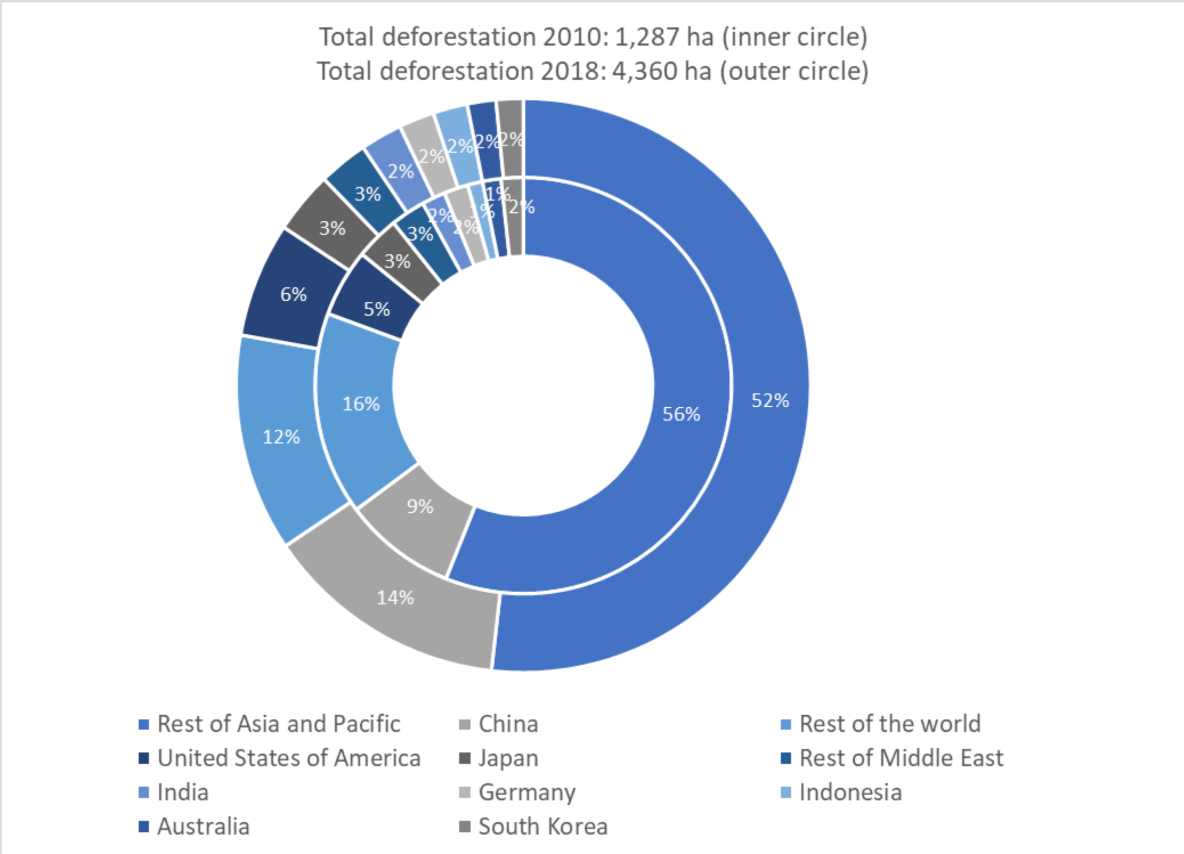
According to Land Matrix (2022), currently between 30,000 and 127,000 hectares (15 to maximum 63 per cent of total Cambodian rubber area harvested[12]) are operational large-scale plantations owned by transnational investors, with an additional 100,000 hectares being contracted, but still not operational. This makes it likely that LSLAs contribute to these cited deforestation-related risks, which entail not only greenhouse gas emissions, but also threats to biodiversity. Although the risk exposure is small compared to palm oil, rubber production is also becoming more relevant in other world regions (Laroche et al., 2022), which makes it a crucial product to include in risk assessments of global agricultural supply chains.

Figure 2 illustrates the distribution of deforestation-related risks of Cambodian rubber production embedded in final consumption goods in distant markets. It is striking that the EU is not one of the main end users of manufactured products containing Cambodian rubber latex. Germany, despite its large automotive and tyre industry, accounts for only 2 per cent of the final consumption of Cambodian rubber. The biggest end-user countries are increasingly located in China. The United States also holds a stable 5 to 6 per cent share in final consumption. This, however, does not mean that Europe, and especially the German tyre industry, does not play a role along the supply chain. It could mean that the manufactured tyres and other products are further exported or that some European companies manufacture abroad. Other sources even state that 25 per cent of Cambodian rubber land is directly linked to the EU tyre industry and European mobility (Laroche et al., 2022). Furthermore, although not extensively covered here, it is important to remember the additional production regions, particularly in Africa, that contribute to supplying European markets. Public references state that large-scale rubber plantations pose a bigger threat to African forests than palm oil (Ainger, 2022; Grogan et al., 2018). Almost all African rubber plantations tied to deforestation are owned by merely three multinational corporations. Together, these enterprises have established deals worth billions of euros with European financial institutions such as Rabobank, BNP Paribas, Deutsche Bank, and Barclays

[12] The lower bound of 15% counts only those Land Matrix deals which are in operation and whose size of operation is larger than zero. The upper bound of 63% also includes those deals in operation whose operation size is unknown. For these cases, we assume the operation size is equal to the contract size, likely leading to an overestimate.

(Global Witness, 2023). Therefore, the EU has a certain leverage effect on regulating rubber-related supply chain risks, but non-EU global downstream markets are relevant stakeholders in shaping the global supply chain transformation.

Figure 2. Consumer country–specific distribution of deforestation-related risks of Cambodian rubber production in 2010 (inner circle) and 2018 (outer circle)



Source: Authors' calculations based on CommodityFootprints.earth (2023).

4 Human rights risks of LSLAs in global supply chains

Due to a lack of data, we cannot directly link human rights violations in LSLAs to global supply chains at the deal level. However, for our analysis we select transnational LSLAs – which are more often linked to global supply chains than domestic LSLAs – to better reflect the risks in global supply chains.

4.1 Evidence from oil palm LSLAs in Indonesia

Increases in oil palm production are mostly driven by cropland expansion (which is well reflected in the deforestation impacts shown above) and not by increases of other inputs such as fertiliser and labour (Abdul et al., 2022; Dalheimer et al., 2022). This increases not only the risk of deforestation, as shown in the previous section, but also displacements of local communities that live under customary tenure arrangements. Land Matrix (2022) reports a substantial proportion of human rights violations related to conflicts around land tenure in Indonesian oil palm deals (Table 2).[13]

Table 2 shows that land-related human rights violations are above the global average for oil palm deals located in Africa and Latin America. For Indonesian oil palm deals, the incidence of displacements is below 4 per cent, falling beneath the global average of LSLA-related displacements. Additionally, Indonesian oil palm deals have a higher percentage of compliance with FPIC regulations compared to LSLAs in other regions. Yet, the share of those deals remains a cause for concern when considering that only 15 per cent of Indonesian palm deals actually report adherence to FPIC. The low absolute numbers are also reflected in the presence of land conflicts for more than a quarter of Indonesian oil palm deals. According to Schleicher et al. (2019), several stakeholders named land conflicts as the most prominent issue of palm oil production in Indonesia. Li (2015) similarly highlights land conflicts as a significant concern, alongside environmental issues. These conflicts are exacerbated due to lack of a single national reference map incorporating all georeferenced data on land use, leading to conflicting information on official maps and overlapping licences among various users (Shahab, 2016). Another reason is the lack of recognition for the communal lands of Indigenous peoples. This is also reflected in the Land Matrix data, which show that negative impacts on local communities are reported in half of the deals. For example, Land Matrix (2022) reports the takeover of Indigenous peoples' customary lands without FPIC processes, and social conflicts repressed by security forces on a large oil palm deal by Wilmar International Ltd (deal #178). There are many other reported cases of conflicts and rejections of deals due to the disrespect of land rights of Indigenous people, illegal fires, and environmental degradation.[14]

In addition, human rights violations occur in the oil palm sector that are not specific to LSLAs but to the production model that often follows these land acquisitions. Due to a limited scope of mechanisation, oil palm cultivation depends more heavily on a sufficient labour supply base compared to other crops, such as maize, wheat, and soybeans (Lay et al., 2021). This factor could also increase the demand for child labour. While country-level evidence suggests that the oil palm expansion did not increase child labour compared to regions without oil palm cultivation (Gehrke & Kubitza, 2021), case studies suggest that young children are involved in collecting loose fruits during harvesting, a task that yields only low payments (Koczberski, 2007). Amnesty International reports specific labour abuses in

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[13] Data coverage for Indonesian oil palm deals in the Land Matrix is comparably high and precise due to recent data collection efforts. It is possible that other regions may substantially underreport the actual extent of conflicts and other land-related human rights violations.

[14] See, for example, deals #191, #195, #3615, and #8115.

the case of global oil palm companies, including child labour, long working hours with low pay, and insecure employment conditions (Amnesty International, 2016).

4.2 Evidence from rubber LSLAs in Cambodia

Similar to palm oil, human rights violations can also be directly linked to LSLAs in the rubber sector. For instance, in many rubber-producing countries such as Cambodia, Vietnam, and Laos, as well as some African countries, national policies have promoted foreign direct investments in land concessions for agricultural production. These investments have affected small-scale farmers' control and tenure of land, and farmers often end up as landless, labouring in often precarious working conditions (Hauser et al., 2015; World Rainforest Movement, 2019). In 2014 a grievance was lodged with the International Criminal Court against the Cambodian government for crimes against humanity. These offenses were linked to an extensive surge in transnational land investments that resulted in the displacement of 770,000 Cambodians. In many instances, local communities and Indigenous groups were forcefully deprived of their lands and woodlands to facilitate the establishment of expansive commercial agricultural ventures – particularly for rubber production (Oehm, 2015). These land-based human rights violations are also reflected in the Land Matrix data, which reports a substantial proportion of human rights violations in Cambodian rubber deals (Land Matrix, 2022). Seven percent of the deals report displacement, and in 35 per cent of the cases the community rejected the land investment. Almost 20 per cent of all land deals report some kind of land conflict, and in one quarter of the investments, consultations did not take place (Table 2). The share of deals associated with human rights violations is notably higher in Cambodian rubber deals and in rubber transactions beyond Cambodia when compared to the global average of LSLAs (Table 2).

In addition, the Bureau of International Labor Affairs (2022) reports instances of child and forced labour associated with rubber production in Myanmar, Cambodia, Indonesia, Liberia, the Philippines, and Vietnam. The report includes cases of physical violence or other punishment in the case of refusal to work. This is not surprising, since cultivating rubber is even more labour-intensive than oil palm cultivation, making it prone to labour abuse.

Table 2. Human rights risks associated with LSLAs

	Indonesian oil palm LSLAs	Global oil palm LSLAs (w/o Indonesia)	Brazilian sugarcane LSLAs	Global sugarcane LSLAs (w/o Brazil)	Cambodian rubber LSLAs	Global rubber LSLAs (w/o Cambodia)	Global agricultural LSLAs
	Number of LSLAs (share of total in %)						
Displacement							
Yes	6 (3.7%)	11 (11.3%)	0	12 (16.0%)	4 (7.0%)	5 (6.9%)	89 (4.8%)
Consultation of communities							
FPIC	24 (14.8%)	7 (7.2%)	0	2 (2.7%)	0	2 (2.8%)	44 (2.4%)
Limited consultation	8 (4.9%)	21 (21.7%)	0	4 (5.3%)	5 (8.8%)	1 (1.4%)	96 (5.2%)
No consultation	8 (4.9%)	10 (10.3%)	0	8 (10.7%)	14 (24.6%)	5 (6.9%)	103 (5.6%)
Community reaction to LSLAs							
Consent	9 (5.6%)	7 (7.2%)	0	0	1 (1.8%)	2 (2.8%)	53 (2.9%)
Mixed reaction	9 (5.6%)	19 (19.6%)	2 (28.6%)	6 (8.0%)	2 (3.5%)	4 (5.6%)	85 (4.6%)
Rejection	11 (6.8%)	18 (18.6%)	0	16 (21.3%)	20 (35.1%)	11 (15.3%)	162 (8.8%)
Presence of conflict							
Yes	41 (25.3%)	17 (17.5%)	0	9 (12.0%)	11 (19.3%)	16 (22.2%)	186 (10.1%)
Negative impacts reported							
Yes	83 (51.2%)	22 (22.7%)	4 (57.1%)	12 (16.0%)	9 (15.8%)	13 (18.1%)	300 (16.3%)
TOTAL	**162**	**97**	**7**	**75**	**57**	**72**	**1838**

Source: Authors' calculations based on Land Matrix (2022).

Note: *Interpretation of the LSLA-specific HR violations reported by the Land Matrix should be treated with caution, because the majority of deals show missing information. Therefore, these human rights risks should be interpreted as a lower bound.*

4.3 Evidence from sugarcane LSLAs in Brazil

As with palm oil, the cultivation of rubber is a labour-intensive task, while sugarcane – at least in Brazil – has a high degree of mechanisation. This is also reflected in the Land Matrix database. For the few but very large and highly mechanised sugarcane deals, hardly any human rights violations have been reported (Land Matrix, 2022). However, some communities have reported negative impacts of the investments, such as decreasing food security (deal # 8727, 8738), contaminated water due to agrochemicals (deal # 768), and deliberate forest fires presumably intended to prevent the locals from entering their former land (deal # 7956). Involved investors are UBE Gruppen AS, Royal Dutch Shell, and Harvard Management Company, which have their origins in Europe and the United States (Land Matrix, 2022). In these highly mechanised production systems, LSLA-related human rights violations occur largely in the early acquisition phases of the land rather than when the deal is already operational and exporting commodities. This poses a significant challenge for sustainability regulations of supply chains. The Land Matrix data are, however, unlikely to be exhaustive in Brazil due to data limitations and lack of transparency regarding land investments. This means that labour abuses on farms may not be recorded in the database, but that does not mean they do not exist. There are indeed indications of child and forced labour in sugarcane production in Brazil. Anecdotal evidence exists for exploitative labour practices as well as child labour and forced labour (Bureau of International Labor Affairs, 2022; Lorenzen, 2021). Some of the plantations involved in these practices had even been granted clearance for certified export to the United States until recently (Teixeira & Sherfinski, 2021).

Sugarcane production is also globally fraught with risks. Table 2 shows that human rights violations in sugarcane deals are particularly high outside of Brazil. Local people are frequently displaced from their lands. There is also often a lack of consultation on the land investments, which often results in severe land conflicts. Additionally, beyond Brazil, sugarcane cultivation is highly labour-intensive due to manual harvesting practices. The reliance on cheap labour renders these plantations susceptible to various forms of labour-related exploitation and abuse. Indeed, there is ample evidence of child and forced labour across the world: child labour on Asian large-scale sugarcane plantations during the harvest season (International Labour Office, 2017), children under the age of 10 being involved in sugarcane production in Zimbabwe, and an estimated 28,303 children engaged in sugarcane work in Vietnam (Bureau of International Labor Affairs, 2022). Also, sugarcane harvesting under hazardous working conditions in increasingly hot weather conditions has been associated with an epidemic of chronic kidney disease, especially in Central America (Glaser et al., 2020).

5 Challenges and unintended consequences of HREDD

As argued in the previous sections, to de-risk these supply chains, regulators and private sector actors must prioritize addressing LSLAs in the global production of primary agricultural products as these involve a variety of severe environmental and human rights risks. Presently, while not exclusively centred on LSLAs, a multitude of supply chain initiatives in the agricultural sector directly or indirectly address the environmental and human rights risks associated with LSLAs. These initiatives encompass collective commitments by groups of stakeholders to reduce, for example, deforestation[15]; individual company pledges with respect to certain targets such as zero deforestation, no exploitation or zero emissions; internal codes of conduct that regulate specific production or sourcing practices; certification programmes for sustainable production; multilateral trade policies; and national sanctions by importer and producer countries (Lambin et al., 2018; Rudloff, 2022). Their success has, however, been mixed (Gollnow et al., 2022; Groom et al., 2022; Heilmayr et al., 2020; Lambin et al., 2018), a reality underscored by sobering reports on the ecological and socio-economic consequences of LSLAs (Lay et al., 2021).

Partly in response to the limited success of these supply chain regulations, policymakers and researchers have advocated a shift towards addressing the demand side. In this context, mandatory HREDD laws which require companies to implement internal processes to identify, prevent, mitigate, and account for the negative impacts of their activities or those of their subsidiaries, subcontractors, and suppliers are becoming a major regulatory instrument (Schilling-Vacaflor & Gustafsson, 2023). These laws have two distinct advantages compared to previous initiatives. First, high-income countries implementing such laws possess the institutional capacities to enforce them, a substantial shortcoming of many private initiatives. Second, participating states could have enough market power to reshape global supply chains, setting the standard for the global market, and other countries could follow suit addressing the weakness of the more limited commitments of single or smaller groups of companies. Consequently, HREDD has the potential to significantly reduce both the environmental and human risks associated with LSLAs. One prominent example in this context is the EU regulation for deforestation-free supply chains. The new regulation is intended to prevent the import of timber, rubber, cocoa, coffee, palm oil, beef, soy, and derivative products into the EU market if their production has caused deforestation. While the regulation does not require companies to identify the specific plot of land on which each regulated commodity is produced, it requires relating large shipments of the commodities to all the plots of land where the primary products were produced. This requirement does not impose the need to track each commodity throughout the entire supply chain but compels upstream producers outside the EU to trace their commodities to LSLAs. This is a significant change of the current business practice and could significantly decrease deforestation (Client Earth, 2022).

[15] Collective commitments by groups of stakeholders include, for instance, the New York Declaration on Forests and the Consumer Goods Forum. However, these commitments do not always translate into quantifiable and targeted regulations.

Despite the potential of these new regulations to address LSLA-specific risks, several caveats remain. Foremost among them is the challenge of limited traceability of commodities along supply chains. Another challenge is that leakage effects could also reduce the efficiency of these regulations in contributing to global reductions. Last, the regulations could also have unintended effects in terms of market concentration and exclusion of smallholders.

5.1 Limited traceability

Global agricultural supply chains are often highly complex, making it challenging to trace products back to their origins. For palm oil, final processing industries and biodiesel refineries located across the world source refined palm oil and kernel palm oil from refineries primarily situated in the main producer countries of oil palm fresh fruit bunches or in important global trade ports. Refineries in turn source crude palm oil and palm kernel oil from palm oil mills. These mills are located in the producer countries due to the rapid deterioration of the FFB, occurring within few days of harvest. FFB are produced either by smallholder farmers who work independently or within contract-farming schemes, or by large-scale plantations (Pacheco et al., 2017) – among them estates owned by foreign investors.

A multitude of initiatives have already targeted the adverse outcomes of palm oil supply chains, facilitating some degree of traceability. The Roundtable on Sustainable Palm Oil (RSPO) is the most common and internationally recognised certification scheme, having been established in 2004 by the World Wildlife Fund (WWF). The set of environmental and social criteria of the RSPO includes protecting primary forests and areas with high conservation value, respecting the rights of workers and communities, and reducing greenhouse gas emissions (Schleicher et al., 2019). In addition to certification schemes, there are also other initiatives, albeit less widespread, that complement the regulations of the RSPO (Schleicher et al., 2019). The oil palm sector is also characterised by a large number of sustainability initiatives at the company level with a focus on zero-deforestation commitments (ZDC). ZDCs in the context of palm oil usually include commitments to no oil palm development on High Carbon Stock (HCS) or High Conservation Value (HCV) areas, no burning, and no new development on peatland regardless of depth, in addition to support of internationally recognized human rights and respect of land tenure rights (Wilmar, 2019). ZDCs require, hence, that the commodity traders and processing industries ensure that they source their production from plantations that operate in line with their policies. In 2020 ZDCs covered 83 per cent of palm oil refining capacity in Indonesia and Malaysia with effective implementation at 78 per cent.

While palm oil is usually traded, processed, and stored in large volumes as a bulk commodity without qualitative differentiation between different consignments, certification schemes and ZDCs require that companies involved in palm oil supply chains trace their production to some extent if they want RSPO-certified production or to implement ZDCs. Ensuring traceability becomes increasingly crucial as mandatory due diligence regulations are gaining prominence in Europe (Directorate-General for Environment, 2021). The RSPO offers, for example, three types of supply chain models with different degrees of traceability: mass balance (MB), segregation (SG), and identity preserved (IP). Mass balance allows certified palm oil to be mixed with non-certified palm oil throughout the supply chain, while segregation requires the strict separation of certified palm oil from non-certified palm oil at every stage of the supply chain. Identity preserved goes a step further by guaranteeing product-level traceability, enabling the tracing of palm oil back to its origin at a specific plantation (RSPO, 2023). The costs for physically separating certified sustainable and conventional products in fragmented and globalised supply chains are, however, high (Gassler & Spiller, 2018). According to the Impact Report of the RSPO, only 5 per cent of RSPO-certified palm oil was certified IP, 44 per cent SG, and 51 per cent MB(RSPO, 2022). In addition, these figures apply only to RSPO-certified palm oil, which represents only 19 per cent of the total Indonesian palm oil supply in 2022. This implies that in numerous instances, consumers cannot be confident that their palm oil product was sourced sustainably and ethically. Despite the fact that 81 per cent of Indonesia's palm oil exports were covered by a ZDC in 2018, an analysis by Trase (2023) reveals that the top exporter groups continued to be linked to significant deforestation exposure in 2015. In fact, companies with ZDCs, responsible for 81 per cent of exports, were responsible for 78 per cent of all deforestation risk at the time (Trase, 2020). Traceability via these schemes remains, hence, limited.

In recent years, however, alongside ZDCs, corporate efforts have been made to improve traceability and thereby the effectiveness of sustainability measures, including trace-to-mill or even stricter trace-to-plantation and trace-to-farm initiatives (Leng, 2022). From 2018 to 2020, 87 per cent of refined palm oil exports were sourced from refineries that publicly reported on the set of mills from which they purchased crude palm oil (Heilmayr & Benedict, 2022). Given the fragmented structures in far upstream and downstream markets and the plethora of sustainability initiatives, large intermediate trading companies – which are often also vertically integrated with processing and manufacturing – have been identified as key actors when it comes to implementing traceability efforts (Zu Ermgassen et al., 2022). According to Trase (2023), Indonesia's palm oil export market has been consistently dominated by four palm oil trading groups, namely Sinar Mas, Musim Mas, Wilmar, and Royal Golden Eagle. The good news is that these large trading groups have established clear goals for achieving full trace-to-plantation for their own and third party–supplying mills and communicate their traceability progress publicly. Sinar Mas, for example, self-declares to have achieved 100 per cent trace-to-mill and

96 per cent trace-to-plantation in their palm oil supply chain, including for third-party mills (Sinar Mas Agro Resources and Technology Tbk, 2023).[16]

Yet, major shortcomings remain. Despite the companies' commitment to achieve full traceability from plantation to the final product, often only lists of supplying mills are disclosed. The plantation names and locations are often not published or are unknown to the company itself. This lack of transparency complicates efforts to trace LSLAs and assess associated risks, particularly when the ownership structure deviates from the physical flow of palm oil.

While Sinar Mas and the other three mentioned traders remain relevant in global supply chains, there are new companies entering the palm oil market that are less transparent concerning their ZDCs. Indonesian-based companies, such as KPN Corp, Astra Agro Lestari, and Citra Borneo Indah, are experiencing rapid growth in exports, which in turn has led to a decline in market power for the traditional traders. The primary markets of these newcomers are Asia and Africa, meaning mostly countries with less strict sustainability requirements are being supplied. Also, while all three companies have pledged to achieve zero deforestation, they did not release traceability reports in 2020, and the average tonne of palm oil exported by these companies has a deforestation risk 1.7 times higher than the industry average (Heilmayr & Benedict, 2022; Trase, 2020); furthermore, any possible human rights violations are thus obscured.

Rubber is also a key component in global supply chains, in particular for the automotive industry (Cho et al., 2022). Similar to palm oil, global supply chains of natural rubber are complex and fragmented. The manufacturing of intermediate natural rubber products is dispersed across the globe (Chanchaichujit & Saavedra-Rosas, 2018; Higgins et al., 2007; Paha et al., 2021). In the rubber industry, consumer goods manufacturers source various intermediate natural rubber products either from global trading companies or directly from intermediate rubber factories, which may be located either in producer countries or abroad.[17] These factories acquire their inputs from rubber factories engaged in the initial processing of rubber, or from associated traders, primarily located in producer countries (Pyay et al., 2019). These actors in turn source natural rubber latex directly from rubber farmers or through local dealers. While large rubber plantations play an increasing role in supplying world markets, natural rubber is still to a large extent produced by smallholder famers as it is – similar to oil

[16] Similar figures are provided by the other big traders in the region: Musim Mas reports 94% trace-to-plantation coverage, including third-party mills. Wilmar and Royal Golden Eagle also state close to full trace-to-mill achievements by 2021, along with 100% trace-to-own plantations. Both companies, however, remain vague about when and how full traceability vis-à-vis third-party suppliers of foreign mills will be achieved. Only approximately 15% of Wilmar's third party–supplying mills are traceable to the plantation level (Forest 500, 2023).

[17] Intermediate products – such as brown crepe, standard block rubber, air-dried sheets, ribbed smoked sheets, pale crepe rubber, and latex concentrate – are necessary for manufacturing up to 50,000 different final products (Pinizzottoa et al., 2021; Salehi et al., 2021).

palm – difficult to mechanise (Gehrke & Kubitza, 2021). Estimates suggest that smallholder farmers make up between 70 and 90 per cent of the total area under rubber cultivation (Carr, 2012; Pinizzottoa et al., 2021). However, large rubber plantations also exist, as documented by Land Matrix data, and are reported to be on the rise in main producing countries in Southeast Asia. Vertically integrated estate farms of major rubber traders exist, for instance, in Malaysia, Indonesia, and India (Chanchaichujit & Saavedra-Rosas, 2018). To date, Land Matrix (2022) data indicate that about 14 per cent of operational rubber land globally is controlled by large-scale investors.

While the connection between land-based risks of downstream production and consumption has long been the focus of public disputes concerning palm oil, attention towards LSLAs for rubber has remained relatively limited. Upcoming HREDD such as the EU regulation on deforestation-free supply chains will, however, also require tracing rubber commodities to their origins. Yet, traceability in the rubber sector involves additional obstacles compared to the palm oil sector. First, the supply chains are even more opaque, with smallholder farmers dominating the production and innumerable traders acting as intermediaries between farmers and processing factories (Inkonkoy, 2021). Second, while FFB of oil palms are highly perishable, natural rubber is not. The supply base of the processors is hence far wider, with 85 per cent of the produce originating from sources located more than 150 kilometres away from the processing factories (Inkonkoy, 2021). Third, due to the relatively limited focus on the sustainability of rubber supply chains, initiatives such as RSPO certification or ZDCs that also require some degree of traceability are less common in the sector. Yet, some exceptions exist.[18] The Forest Stewardship Council (FSC) has been certifying sustainable forest management of rubber plantations; this engenders habitat protection by designating buffer zones and cleaner water due to minimal use of chemical pesticides and fertilisers (Kennedy et al., 2016). The Global Platform for Sustainable Natural Rubber (GPSNR), a multi-stakeholder platform including various supply chain actors, obliges members to align their procurement policies to GPSNR's own sustainability requirements and to report annually on progress towards policy components. This platform could have the leverage to transform the entire sector due to its size, covering 50 per cent of global natural rubber volume; first analyses show that GPSNR members scored higher than non-GPSNR members on Environmental, Social and Governance (ESG) disclosures (Inkonkoy, 2021). On the other hand, certifications in the rubber sector are mostly found in relatively short value chains with high degrees of vertical integration where traceability is less problematic, and only a few major rubber companies have actually succeeded in tracing their production (Inkonkoy, 2021; Kennedy et al., 2016). Therefore, the effectiveness of these relatively new standards remains to be seen.

[18] There are also a handful of other private sector–led initiatives, though these often evince limited success (Cho et al., 2022; Kongmanee & Ahmed, 2020).

Similar to natural rubber and palm oil, sugarcane-related products have become key commodities in global value chains over the past few decades. Sugarcane accounts for 86 per cent of the world's sugar supply; 75 per cent of total sugarcane produce is used for sweeteners and molasses in processed food and beverages, while the other 25 per cent is used for the production of biofuels (Voora et al., 2020). The sugarcane value chain shows similar features to palm oil and rubber supply chains. Sugar is a bulk commodity and embedded in complex global supply chains. The manufacturing of raw or refined sugar is widely distributed across the globe (Higgins et al., 2007; Paha et al., 2021). Mills are close to the plantations, with an average distance of about 25 kilometres, as sugarcane needs to be processed promptly after harvesting. The mills then produce raw sugar, which is usually either transported to storage facilities at shipping terminals destined for export or to sugar refineries. After milling, the sugar is further refined, either domestically or in distant export markets. The refined sugar enters the grocery or wholesale markets directly or its final manufacturing stage in the food and beverage industries, or in fuel manufacturing (Jenkins et al., 2015). At the production level, the sugar industries show, however, substantial heterogeneity across countries with respect to farm concentration, ownership structure, and mechanisation degree (Higgins et al., 2007). In many developing countries, sugarcane is produced by individual small to middle-sized farms with an average size between 20 and 200 hectares that sustain the livelihoods of 100 million people across the world (Voora et al., 2020). In these countries, sugarcane is primarily harvested by hand, a very labour-intensive task, similar to oil palm and rubber. In Brazil and the United States, however, cultivation is highly mechanised and controlled by the respective milling companies (Cardoso et al., 2019; Higgins et al., 2007).

In theory, as sugarcane requires rapid processing, traceability should be simpler compared to the fragmented rubber sector. However, the demand for sustainably produced sugar is a relatively new development and consumers are generally willing to pay higher prices for such products only to a limited extent. Economic incentives to establish traceability are hence lacking in the industry. This lack of product traceability throughout the value chain positions sugarcane-related products as one of the commodity groups with the least transparency. Nevertheless, a few certification schemes do exist as a response to the well-known human rights risks described above. Bonsucro, established in 2008, has become the largest private standard in the sugarcane sector, with 1.5 million hectares certified globally (Bonsucro, 2023). There are voices, though, claiming that the scheme, whose certification is recognised by the European Commission, is ineffective, because it has routinely failed to detect abuse (Teixeira & Sherfinski, 2021). Other certification schemes, such as the Rainforest Alliance or the Proterra Foundation, intend to extend certification to sugarcane but have limited relevance (Voora et al., 2020). The landscape could, change, however, as there is a rising desire among consumers for more eco-friendly food and energy options, and governments are implementing more rigorous policies and regulations vis-à-vis supply chain risks (Voora et al., 2020).

5.2 Supply chain divergence

High-income countries regulating the risks posed by LSLAs by implementing HREDD carries the risk of unsustainable production being sold in markets where such stringent standards are not mandated. HREDD regulations require only that the companies based in import countries address deforestation risks and human rights violations in their own supply chain. This allows producers to integrate plantations and farms acquired through large-scale acquisitions that do not involve high environmental and human rights risks into supply chains that cater to Western markets, while more problematic LSLAs are the source of potential South–South trade or the domestic market. In the end, regions with little oversight regarding human rights violations and deforestation could become hotspots for domestic or regional supply chains. This might lead to unchanged or even increased human rights violations and deforestation incidences at a global or national scale.

For instance, over the past two decades, the most important import entities of Indonesian palm oil have been India and the European Union. However, other actors are increasingly entering the market. Table 3 shows that, in more recent years, Pakistan has reached import volumes close to those of the European Union, followed by Bangladesh, the United States, Malaysia, and Egypt. In addition, by 2021 China had emerged as the largest direct importer of Indonesian palm oil, while the European Union's significance as an export market has been declining over time.

Table 3. Indonesian crude and refined palm oil exports in tonnes to its core global destination markets

		Crude and refined palm oil export shares			
	Total palm oil exports in tonnes	4,109,998	16,291,778	27,893,589	25,531,772
Importer	**India**	39.9%	32.5%	22.7%	11.9%
	EU27	22.0%	16.6%	13.3%	11.0%
	China	10.7%	13.3%	12.8%	16.7%
	Pakistan	0.4%	0.6%	8.8%	10.4%
	Bangladesh	2.3%	4.7%	5.0%	5.1%
	Malaysia	1.4%	9.1%	3.8%	4.5%
	Egypt	0.9%	3.0%	3.3%	3.9%
	USA	0.5%	0.2%	3.3%	5.5%
	RoW	22.0%	19.9%	27.0%	31.0%
	Year	**2000**	**2010**	**2018**	**2021**

Source: Authors' own calculations based on data from FAOSTAT (2023).

The relative importance of the EU is also decreasing for rubber exports from Cambodia and Côte d'Ivoire. Côte d'Ivoire exports both rubber in primary forms and processed rubber. The most important

Ivorian rubber trading partner has historically been the EU, and exports continue to increase in absolute terms. However, other actors have emerged as important importers of Ivorian rubber over the past decade. By 2021 Malaysia's market share had surpassed even that of the EU in direct imports of Ivorian rubber, while China accounted for more than 17 per cent of all imports (see Table 4). For Cambodian rubber, the EU has never been an important direct trade partner. Likely due to proximity and land-investor relations,[19] Vietnam has historically been the most important direct buyer of Cambodian rubber, with an increase in absolute and relative terms; in turn, Vietnam exports the produce to not only China, but also Germany and the Netherlands. Other significant destination markets include Malaysia, China, and India, with some fluctuations observed over the past few years (see Table 4). Similar to palm oil, the emergence of these new import markets signifies a shift in global market power, thereby influencing the scope of sustainability initiatives.

[19] There are 22 companies registered in Vietnam investing in Cambodian rubber plantations (Land Matrix, 2022).

Table 4. Rubber exports (in primary and other-than-primary forms) in tonnes from Côte d'Ivoire and Cambodia to their core global destination markets

Importer	Total rubber exports in tons	Share of rubber exports from Côte d'Ivoire				Share of rubber exports from Cambodia			
		123,662	240,625	686,503	1,135,135	12,386	26,872	155,784	256,229
	China	0.0%	4.5%	6.1%	17.1%	0.0%	7.1%	10.2%	4.7%
	EU27	77.7%	56.8%	36.8%	25.7%	0.0%	0.0%	1.1%	1.3%
	India	0.0%	2.3%	5.2%	5.7%	0.0%	0.5%	11.8%	1.4%
	Malaysia	0.0%	13.4%	33.6%	30.7%	42.8%	8.9%	12.7%	6.7%
	Singapore	0.5%	0.0%	2.4%	0.2%	29.5%	2.3%	6.0%	2.3%
	South Korea	0.0%	0.0%	0.0%	0.0%	1.2%	1.8%	1.1%	1.2%
	USA	1.6%	11.3%	8.5%	8.2%	0.0%	0.0%	0.0%	0.1%
	Vietnam	0.0%	0.0%	0.0%	0.0%	24.3%	72.9%	54.5%	73.3%
	RoW	20.2%	11.8%	12.1%	12.3%	2.2%	6.5%	2.6%	9.0%
		2000	**2010**	**2018**	**2021**	**2000**	**2010**	**2018**	**2021**
		Year				**Year**			

Source: Authors' own calculations based on data from FAOSTAT (2023).

A variety of sugarcane-based products are traded in international markets. In Brazil, the three major trade products are raw cane, refined sugar, and ethanol. For raw cane, Brazil holds more than 50 per cent of the global market share; for refined sugar the figure stands at 10 per cent.[20] As shown in Table 5, Brazil plays a key role in South–South sugar trade, supplying many African countries and the Middle East. This holds for both raw sugar and refined sugar exports. In earlier years, Russia and the EU were among the major raw sugar importers, but in recent years the EU's and Russia's relevance has diminished. The single most important importer for Brazilian raw sugar today is China. The EU's import share has decreased from almost 9 per cent to 2 per cent since the year 2000, while China's import share has increased from 0 to 18 per cent in recent years. These numbers reflect a shift in market power away from the EU towards China and other emerging economies that are increasingly dominating agricultural markets.

[20] Although the literature states that in the 2019–2020 crop year, 65.1% of the produced sugar (TRS) in Brazil was allocated for ethanol production (Cursi et al., 2022), there is no detailed ethanol trade data, so we exclude it from the further discussion and focus on the sugar trade.

Table 5. Brazilian raw and refined sugar exports in tonnes to its core global destination markets

Importer	Raw sugar exports 2000	Raw sugar exports 2010	Raw sugar exports 2018	Raw sugar exports 2021	Refined sugar exports 2000	Refined sugar exports 2010	Refined sugar exports 2018	Refined sugar exports 2021
Total Brazilian exports in tonnes	**4,308,082**	**20,936,204**	**18,204,862**	**23,972,018**	**2,158,222**	**7,060,793**	**3,100,570**	**3,258,070**
Asia (excl. China)	7%	26%	29%	22%	7%	15%	1%	1%
China	0%	6%	4%	18%	0%	0%	0%	1%
Africa	10%	14%	29%	25%	42%	39%	58%	71%
Middle East	24%	23%	26%	14%	36%	38%	26%	8%
Americas (excl. CAN, USA, VEN)	2%	1%	1%	6%	5%	3%	7%	4%
Canada	4%	3%	5%	5%	2%	2%	0%	0%
USA	5%	2%	1%	1%	0%	1%	4%	3%
Venezuela	0%	4%	2%	1%	0%	1%	1%	6%
RoE (excl. Russia, EU27)	1%	2%	0%	3%	1%	0%	0%	5%
Russia	40%	17%	1%	2%	7%	0%	0%	0%
EU27	8%	4%	1%	2%	0%	1%	2%	1%

Source: Authors' own calculations based on data from FAOSTAT (2023).

Notes: Despite the described sugarcane trade relationships, Brazilian sugarcane LSLAs are still dominated by investors based in Europe, the USA, Australia, and Canada, with just a few investors from India and China. Land Matrix (2022) data indicates that more than 10% of sugarcane land is controlled by these international investors, which bears risks for the local population but also opportunities for enforcing sustainable practices even when trade flows shift to less-regulated purchasing countries.

RoE stands for Rest of Europe.

We conclude that leakage is particularly likely where companies operating LSLAs have access to processing facilities and consumer markets outside the countries regulated by HREDD. As shown above, this is the case for all reviewed commodities in this study. This market structure has already been problematic for other sustainability measures, which were similarly confined to specific subsets of companies such as ZDCs for palm oil production. While many large international palm oil refiners and traders now have ZDC-anchored sourcing policies, many refineries in India, Pakistan, and China still source crude palm oil without any sustainability requirements. India, for example, is the largest refining market outside of Southeast Asia, but only 35 per cent of its refineries are covered by ZDC policies (Steinweg et al., 2017; ten Kate et al., 2020). At the same time, India is one of the largest importers of crude palm oil from Indonesia (see Table 3); it is mostly used for domestic consumption. This exemplifies companies involved in LSLAs retaining access to supply chains and large consumer markets that are situated completely beyond the jurisdiction of HREDD-implementing countries. Leakage effects are even more likely for rubber and sugarcane. This is because sugarcane is particularly active in South–South trade, and only a minor fraction of produce goes to the European market. For rubber, the biggest direct importers are in Asia, and China is emerging as a significant consumer of rubber, providing ample opportunity to redirect unsustainable products to these markets.

5.3 Restructuring global supply chains: Marginalisation, market concentration, and regionalisation

The decision by companies to disengage from certain high-risk regions or suppliers could lead to economic repercussions for vulnerable communities, workers, and small-scale producers who rely on these supply chains for their livelihoods.

In the context of producers, Section 2 illustrated that the upstream producers in global palm oil supply range from large-scale plantations to small independent smallholders. In the rubber sector, smallholders comprise the majority in terms of production share. While traceability remains relatively straightforward for production stemming from large-scale plantations, the inclusion of smallholders introduces additional complexities due to the challenges of monitoring dispersed individual production units. Longer supply chains with the strong involvement of local traders further compound these complexities. These complex supply chains severely impede traceability, since often neither smallholder farmers nor local traders keep records, which threatens the claims of downstream companies using third-party suppliers that their commodities originate from deforestation-free production (Lyons-White & Knight, 2018).

Nevertheless, lessons from successful traceability in smallholder production within global supply chains can be drawn from certification standards. In the cocoa sector, approximately one quarter of cocoa production areas are already certified by standards which require traceability and independent auditing (Lernoud et al., 2018). With respect to enforcement and capacity building, companies committed to both zero deforestation and smallholder inclusion balanced these commitments by rarely excluding smallholder farmers based on ZDC violations, instead imposing capacity-building programmes (Grabs et al., 2021). Traceability, also including smallholders, will in the end depend on dissemination and capacity-building efforts by downstream companies. Capacity building within ZDCs has mainly targeted large-scale plantations and palm oil mills; smallholder farmers have been addressed only to a lesser extent (Grabs et al. 2021). In general, while potentially foregone export premiums to HREDD-compliant countries could limit smallholder farmers' profits, domestic markets and South–South trade remain viable avenues.

Apart from the potential exclusion of small producers, these regulations could also impact market access in regions with LSLAs with high-risk profiles. Given the challenges in assessing company-specific risks, driven in part by data scarcity as discussed in Section 2, regional evaluations could serve as a practical alternative. This could result in LSLAs from high-risk regions, along with their workers, facing exclusion from global supply chains regardless of their individual efforts to move their companies towards more sustainable production, leaving the domestic market or regional trade as the only possible venues. However, these supply chains often provide lower wages and fewer safeguards (J. Swinnen et al., 2020; J. F. M. Swinnen, 2007), which could worsen the often already dire socio-economic situation in these regions. An important example of this are the densely forested, conflict-ridden and still relatively poor regions of Papua at a high risk for deforestation and social conflicts, compared to long-standing centres of plantation agriculture such as the already largely deforested lowland regions of Sumatra or the continental parts of Malaysia.

In addition to the marginalisation of smallholder farmers and high-risk regions, the new regulations might also foster market concentration and regionalisation. As outlined in Section 2, global supply chains can be complex, involving multiple tiers of suppliers across different countries. It can be difficult for companies to ensure compliance throughout the entire chain, especially given limited visibility and control over lower-tier suppliers. The regulation of LSLA-associated risks through HREDD and the ensuing traceability measures along supply chains could potentially catalyse restructuring within affected sectors.

The first effect could be that larger companies have a competitive advantage in complex global supply chains that include LSLAs due to significant fixed costs to acquire the necessary expertise and to set up and maintain administrative divisions to assess and monitor supply chains effectively. This could crowd out smaller enterprises. Second, LSLAs catering to regulated markets could be included into integrated supply chains where risks are more manageable (Lyons-White & Knight, 2018). Third, for operating companies of LSLAs, particularly smaller ones, that are not part of integrated supply chains, the importance of South–South trade and domestic markets will likely rise. These companies could prove particularly problematic when it comes to eliminating deforestation and human rights risks, not solely within specific supply chains but across various commodities and potentially even countries. A fourth effect could involve shorter and more regional value chains strategically avoiding additional monitoring costs, for example by using local rapeseed as feedstock for biodiesel production as opposed to palm oil from Southeast Asia. This trend is more likely to occur for commodity groups where competitive substitutes are available.

Overall, large-scale commodity traders and downstream companies developing targeted capacity-building initiatives and designing efficient procedures in case of violations will remain crucial to ensuring the continued inclusion of smallholder farmers. Notably, several major global palm oil traders have already committed to smallholder inclusion through the RSPO standard (RSPO, 2018). In addition, procedures and monitoring requirements should allow for the inclusion of producers from high-risk regions, safeguarding development prospects for these areas. Such endeavours are critical because of potential trade-offs between compliant supply chains and local economic development. Smallholder farmers are still the backbone of many rural economies in the Global South, and numerous regions heavily rely on agricultural export. In a broader sense, if HREDD emerges as an efficient regulatory instrument, it holds the potential to realign the trajectory of LSLAs within their existing supply chains, having potentially large implications for the on-the-ground impact of LSLAs and for their importance in global supply chains.

6 Conclusion

The report analyses the specific human rights and deforestation risks related to large-scale land acquisitions (LSLAs) in three major global agricultural supply chains – palm oil, rubber, and sugarcane. Our data show that in all three supply chains LSLAs have targeted millions of hectares of land in the Global South while also playing a key role in global production. If future HREDD is to reduce deforestation and human rights risks in these supply chains, it is essential to consider the risks posed by LSLAs in these countries.

While all three sectors are related to deforestation risks in their respective production countries, substantial variation in intensity exists. LSLAs in the palm oil sector show by far the highest deforestation risks – especially compared to sugarcane, where LSLAs mostly occurred on pastureland. This is partly due to the cluster of LSLAs for palm oil production in Indonesia where new concessions were commonly granted on previously abundant tropical forestland. Additionally, production capacities for palm oil were primarily built up through expanding plantations and not by increasing yields. The rubber sector also shows high deforestation risks in some countries, especially in Southeast Asia, but to a much smaller extent than palm oil due to its lower global production volume.

Human rights violations due to LSLAs are primarily related to the displacement of local communities and the lack of consent or even consultation. For Indonesian oil palm deals, the incidence of displacements is below the global average of LSLA-related displacements. This is likely due to the historic expansion of oil palm plantations into Indonesian forestland with low population densities. However, our data show that land-related human rights violations are above the global average for oil palm deals located in Africa and Latin America. Furthermore, other human rights risks, while not directly related to the acquisition process, are also often associated with large-scale plantation agriculture that depends on wage labour. For instance, severe labour abuses are frequently exacerbated by the limited scope for mechanisation in oil palm and rubber cultivation. In the highly mechanised sugarcane production systems in Brazil few human rights violations are recorded: Few labour rights violations occur when the deal is already operational, as little labour is needed in sugarcane cultivation in Brazil, and violations related to evictions often started years or even decades ago in the region, making them difficult to trace.

The emergence of binding HREDD, particularly in the European Union, underscores a growing recognition of the necessity to hold companies accountable for environmental degradation and human rights abuses, including those stemming from LSLAs. Our analysis suggests, however, that the lack of traceability in the reviewed supply chains will pose a significant challenge. Yet, there are also important differences between sectors regarding their current level of traceability. For instance, the rubber sector has been targeted to a lesser extent by international sustainability initiatives than the palm oil sector in recent decades, resulting in relatively limited traceability. Moreover, the prevalence of fragmented and complex supply chains, particularly with smallholders dominating production in certain regions, adds to the difficulty of tracing products along supply chains that involve rubber. Albeit the significant risks in palm oil production, the sector shows the highest level of transparency due to multiple global sustainability initiatives that target the sector and involve a certain degree of traceability. In the sugar sector, despite shorter supply chains in certain production hotspots such as Brazil, there has also been limited economic incentive to establish traceability in the past; sugar is one of the least transparent agricultural commodities.

In addition, the emergence of new markets for palm oil, rubber, and sugarcane has led to a shift in global market dynamics, with far-reaching implications for HREDD law in Europe. For all three commodities, the EU is no longer the major export market: Asian countries, in particular, have emerged as major direct import markets as well as final consumption markets. This enables producers to include plantations and farms acquired through inconspicuous large-scale acquisitions into supply chains serving Western markets. Simultaneously, high-risk LSLAs could potentially act as sources for South–South trade or the domestic market. Apart from possibly being not very effective, HREDD might provide large-scale production units – and, with that, LSLAs – a comparative advantage, while disadvantaging regions with weak governance structure.

It is also concerning that sectors such as sugarcane, which are less associated with deforestation, highly mechanised, and consequently, involve fewer labour abuses, might meet HREDD requirements more readily. However, these sectors might have previously been involved in significant human rights violations linked to LSLAs and displacements of local communities – which are often difficult to trace in the region since most acquisitions processes happened decades ago. This temporal lag complicates tracing and providing evidence, making it challenging to establish accountability. In addition, unlike deforestation, the specific articles in current HREDD related to forced evictions and the deprivation of land leave considerable room for interpretation. For instance, the German supply chain act and the CSDDD prohibit only those acquisitions of land that are essential to a person's livelihood. Although, it remains to be seen how the laws are applied in practice, this could affect pastoralists, who often access large swathes of land under customary tenure. While HREDD laws may effectively address labour rights violations and deforestation associated with large-scale farming, they may not adequately regulate the direct human rights risks linked to land, such as evictions and displacements.

In summary, while HREDD legislation holds the potential to address deforestation and human rights risks in global supply chains stemming from LSLAs, sectors have different starting points, and human rights violations directly associated with LSLAs are difficult to trace due both to the often complicated and overlapping land claims in many countries and to the substantial time lag. Overall, future HREDD that aims to address the sustainability of global agricultural supply chains must pay more attention to the severe human rights violations that are related to the practice of large-scale land acquisitions.

7 References

Abdul, I., Sari, D. W., Haryanto, T., & Win, T. (2022). Analysis of factors affecting the technical inefficiency on Indonesian palm oil plantation. *Scientific Reports 2022 12:1*, *12*(1), 1–9. https://doi.org/10.1038/s41598-022-07113-7

Ainger, J. (2022). *Europe’s Rubber Addiction Destroys Africa’s Tropical Forests - Bloomberg*. https://www.bloomberg.com/news/articles/2022-06-15/europe-s-rubber-addiction-is-killing-africa-s-tropical-forests?in_source=embedded-checkout-banner#xj4y7vzkg

Amnesty International. (2016). *The Great Palm Oil Scandal: Labour abuses behind big brand names*. https://www.amnesty.org/en/documents/asa21/5243/2016/en/

Bonsucro. (2023). *Bonsucro - The global platform for sustainable sugarcane*. https://bonsucro.com/

Bureau of International Labor Affairs. (2022). *List of Goods Produced by Child Labor or Forced Labor - U.S. Department of Labor*. https://www.dol.gov/agencies/ilab/reports/child-labor/list-of-goods

Cardoso, T. F., Watanabe, M. D. B., Souza, A., Chagas, M. F., Cavalett, O., Morais, E. R., Nogueira, L. A. H., Leal, M. R. L. V., Braunbeck, O. A., Cortez, L. A. B., & Bonomi, A. (2019). A regional approach to determine economic, environmental and social impacts of different sugarcane production systems in Brazil. *Biomass and Bioenergy*, *120*, 9–20. https://doi.org/10.1016/J.BIOMBIOE.2018.10.018

Carr, M. K. V. (2012). The water relations of rubber (hevea brasiliensis): a review. *Experimental Agriculture*, *48*(2), 176–193. https://doi.org/10.1017/S0014479711000901

Chanchaichujit, J., & Saavedra-Rosas, J. F. (2018). The Elements of the Natural Rubber Industry Supply Chain. In J. Chanchaichujit & J. F. Saavedra-Rosas (Eds.), *Using Simulation Tools to Model Renewable Resources: The Case of the Thai Rubber Industry* (pp. 19–40). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-55816-5_2

Cho, K., Goldstein, B., Gounaridis, D., & Newell, J. P. (2022). Hidden risks of deforestation in global supply chains: A study of natural rubber flows from Sri Lanka to the United States. *Journal of Cleaner Production*, *349*, 131275. https://doi.org/10.1016/J.JCLEPRO.2022.131275

Client Earth. (2022). *Getting to "deforestation-free": Clarifying the traceability requirements in the proposed EU deforestation regulation*. https://www.clientearth.org/latest/documents/getting-to-deforestation-free-clarifying-the-traceability-requirements-in-the-proposed-eu-deforestation-regulation/

CommodityFootprints.earth. (2023). *The Global Environmental Impacts of Consumption (GEIC) Indicator*. https://commodityfootprints.earth/

Croft, S., West, C., Harris, M., Green, J., Molotoks, A., Harris, V., & Way, L. (2022). *Technical documentation for an experimental statistic estimating the global environmental impacts of consumption: 2022 version. JNCC Report No. 715*. https://hub.jncc.gov.uk/assets/7a4063c9-a221-4ca1-ab6a-3b2fae544b32

Cursi, D. E., Hoffmann, H. P., Barbosa, G. V. S., Bressiani, J. A., Gazaffi, R., Chapola, R. G., Junior, A. R. F., Balsalobre, T. W. A., Diniz, C. A., Santos, J. M., & Carneiro, M. S. (2022). History and Current Status of Sugarcane Breeding, Germplasm Development and Molecular Genetics in Brazil. *Sugar Tech*, *24*(1), 112–133. https://doi.org/10.1007/S12355-021-00951-1/TABLES/6

Dalheimer, B., Kubitza, C., & Brümmer, B. (2022). Technical efficiency and farmland expansion: Evidence from oil palm smallholders in Indonesia. *American Journal of Agricultural Economics*, *104*(4), 1364–1387. https://doi.org/10.1111/AJAE.12267

Davis, K. F., Müller, M. F., Rulli, M. C., Tatlhego, M., Ali, S., Baggio, J. A., Dell'Angelo, J., Jung, S., Kehoe, L., Niles, M. T., & Eckert, S. (2023). Transnational agricultural land acquisitions threaten biodiversity in the Global South. *Environmental Research Letters*, *18*(2), 24014. https://doi.org/10.1088/1748-9326/ACB2DE

Directorate-General for Environment. (2021). *Proposal for a regulation on deforestation-free products*. https://environment.ec.europa.eu/publications/proposal-regulation-deforestation-free-products_en

European Coalition for Corporate Justice. (2019). *Over 100 NGOs demand human rights and environmental due diligence legislation*. https://corporatejustice.org/news/over-100-ngos-demand-human-rights-and-environmental-due-diligence-legislation/

FAOSTAT. (2023). *FAOSTAT*. https://www.fao.org/faostat/en/#home

Flachsbarth, I., Lay, J., Nolte, K., Harding, A., Anseeuw, W., & Bourgoin, J. (2020). *Responsible Large-Scale Agricultural Investments in and by G20 Countries: a Call for More Transparency.* https://www.giga-hamburg.de/en/publications/contributions/responsible-large-scale-agricultural-investments-g20-countries-transparency

Follador, M., Soares-Filho, B. S., Philippidis, G., Davis, J. L., Oliveira, A. R. d., & Rajão, R. (2021). Brazil's sugarcane embitters the EU-Mercosur trade talks. *Scientific Reports*, *11*(1), 1–10. https://doi.org/10.1038/s41598-021-93349-8

Forest 500. (2023). *Company Rankings | Forest 500*. https://forest500.org/rankings/companies

Gassler, B., & Spiller, A. (2018). Is it all in the MIX? Consumer preferences for segregated and mass balance certified sustainable palm oil. *Journal of Cleaner Production*, *195*, 21–31. https://doi.org/10.1016/J.JCLEPRO.2018.05.039

Gehrke, E., & Kubitza, C. (2021). Agricultural Productivity and Fertility Rates: Evidence from the Oil Palm Boom in Indonesia. *Journal of Human Resources*, 0520-10905R1. https://doi.org/10.3368/JHR.0520-10905R1

Gibon, V. (2012). Palm Oil and Palm Kernel Oil Refining and Fractionation Technology. *Palm Oil: Production, Processing, Characterization, and Uses*, 329–375. https://doi.org/10.1016/B978-0-9818936-9-3.50015-0

Glaser, J., Hansson, E., Weiss, I., Wesseling, C., Jakobsson, K., Ekström, U., Apelqvist, J., Lucas, R., Monge, E. A., Peraza, S., Hogstedt, C., & Wegman, D. H. (2020). Original research: Preventing kidney injury among sugarcane workers: promising evidence from enhanced workplace interventions. *Occupational and Environmental Medicine*, *77*(8), 527. https://doi.org/10.1136/OEMED-2020-106406

Global Forest Watch. (2023). *Laos Deforestation Rates & Statistics | GFW*. https://www.globalforestwatch.org/dashboards/country/LAO/

Global Witness. (2023). *European rubber imports are driving the destruction of African forests*. https://www.globalwitness.org/en/campaigns/forests/rubbed-out/

Gollnow, F., Cammelli, F., Carlson, K. M., & Garrett, R. D. (2022). Gaps in adoption limit the current and potential effectiveness of zero-deforestation supply chain policies for soy. *Environmental Research Letters*, *17*(1), 114003. https://doi.org/10.1088/1748-9326/ac97f6

Grogan, K., Pflugmacher, D., Hostert, P., Mertz, O., & Fensholt, R. (2018). Unravelling the link between global rubber price and tropical deforestation in Cambodia. *Nature Plants 2018 5:1*, *5*(1), 47–53. https://doi.org/10.1038/s41477-018-0325-4

Groom, B., Palmer, C. E., & Sileci, L. (2022). Carbon emissions reductions from Indonesia's moratorium on forest concessions are cost-effective yet contribute little to Paris pledges. *Proceedings of the National Academy of Sciences of the United States of America*, *119*(5), e2102613119. https://doi.org/10.1073/PNAS.2102613119/SUPPL_FILE/PNAS.2102613119.SAPP.PDF

Halabi, S., & Lin, C.-F. (2017). Assessing the Relative Influence and Efficacy of Public and Private Food Safety Regulation Regimes: Comparing Codex and GlobalG.A.P. Standards. *Food and Drug Law Journal*, *72*(2), 262–294.

Hauser, I., Martin, K., Germer, J., He, P., Blagodatskiy, S., Liu, H., Krauß, M., Rajaona, A., Shi, M., Pelz, S., Langenberger, G., Zhu, C. D., Cotter, M., Stürz, S., Waibel, H., Steinmetz, H., Wieprecht, S., Fror, O., Ahlheim, M., . . . Cadisch, G. (2015). Environmental and socio-economic impacts of rubber cultivation in the Mekong region: Challenges for sustainable land use. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, *10.* https://doi.org/10.1079/PAVSNNR201510027

Heilmayr, R., & Benedict, J. (2022). *Indonesia makes progress towards zero palm oil deforestation.* Trase. https://trase.earth/insights/indonesia-makes-progress-towards-zero-palm-oil-deforestation

Heilmayr, R., Rausch, L. L., Munger, J., & Gibbs, H. K. (2020). Brazil's Amazon Soy Moratorium reduced deforestation. *Nature Food*, *1*(12), 801–810. https://doi.org/10.1038/s43016-020-00194-5

Higgins, A., Thorburn, P., Archer, A., & Jakku, E. (2007). Opportunities for value chain research in sugar industries. *Agricultural Systems*, *94*(3), 611–621. https://doi.org/10.1016/J.AGSY.2007.02.011

Hurni, K., & Fox, J. (2018). The expansion of tree-based boom crops in mainland Southeast Asia: 2001 to 2014. *Http://dx.Doi.Org/10.1080/1747423X.2017.1291766*, *13*(1-2), 198–219. https://doi.org/10.1080/1747423X.2018.1499830/SUPPL_FILE/TLUS_A_1499830_SM5342.ZIP

Inkonkoy, F. (2021). *Sustainability in the natural rubber supply chain: Getting the basics right.* SPOTT & Zoological Society of London. https://www.spott.org/wp-content/uploads/sites/3/dlm_uploads/2022/06/SPOTT-Rubber-Report-Singles-Jun-22-update.pdf

International Labour Office. (2017). *Child labour in the primary production of sugarcane*. https://www.ilo.org/ipec/Informationresources/WCMS_IPEC_PUB_29635/lang-en/index.htm

Jenkins, B., Baptista, P., & Porth, M. (2015). *Collaborating for Change in Sugar Production: Building Blocks for Sustainability at Scale.* The CSR Initiative at the Harvard Kennedy School and Business Fights Poverty. https://www.hks.harvard.edu/sites/default/files/csri-bfp-building-blocks-for-sustainable-sugar.pdf

Johansson, E. L., Fader, M., Seaquist, J. W., & Nicholas, K. A. (2016). Green and blue water demand from large-scale land acquisitions in Africa. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(41), 11471–11476. https://doi.org/10.1073/pnas.1524741113

Junquera, V., Meyfroidt, P., Sun, Z., Latthachack, P., & Grêt-Regamey, A. (2020). From global drivers to local land-use change: understanding the northern Laos rubber boom. *Environmental Science & Policy*, *109*, 103–115. https://doi.org/10.1016/J.ENVSCI.2020.04.013

Kennedy, S. F., Leimona, B., & Yi, Z. F. (2016). Making a green rubber stamp: emerging dynamics of natural rubber eco-certification. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *13*(1), 100–115. https://doi.org/10.1080/21513732.2016.1267664

Koczberski, G. (2007). Loose Fruit Mamas: Creating Incentives for Smallholder Women in Oil Palm Production in Papua New Guinea. *World Development*, *35*(7), 1172–1185. https://doi.org/10.1016/J.WORLDDEV.2006.10.010

Kongmanee, C., & Ahmed, F. (2020). *Assessing Socio-Economic Characteristics of FSC Certified Rubber Farmers and Their Attitudes to Apply FSC Standards in Rubber Plantation: A Case Study in Thailand*. https://papers.ssrn.com/abstract=3712791

Lambin, E. F., Gibbs, H. K., Heilmayr, R., Carlson, K. M., Fleck, L. C., Garrett, R. D., Yann Le Polain De Waroux, McDermott, C. L., McLaughlin, D., Newton, P., Nolte, C., Pacheco, P., Rausch, L. L., Streck, C., Thorlakson, T., & Walker, N. F. (2018). The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change*, *8*(2), 109–116. https://doi.org/10.1038/s41558-017-0061-1

Land Matrix. (2022). *Land Matrix*. https://landmatrix.org

Laroche, P. C. S. J., Schulp, C. J. E., Kastner, T., & Verburg, P. H. (2022). Assessing the contribution of mobility in the European Union to rubber expansion. *Ambio*, *51*(3), 770–783. https://doi.org/10.1007/S13280-021-01579-X/TABLES/3

Lay, J., Anseeuw, W., Eckert, S., Flachsbarth, I., Kubitza, C., Nolte, K., & Giger, M. (2021). *Taking stock of the global land rush: Few development benefits, many human and environmental risks. Analytical Report III*. Bern Open Publishing. https://doi.org/10.48350/156861

Leng, K. Y. (2022). *As war drives up the price of palm oil, is sustainable production at risk?* https://chinadialogue.net/en/food/as-war-drives-up-the-price-of-palm-oil-is-sustainable-production-at-risk-2/

Li, T. M. (2015). *Front Matter from Social impacts of oil palm in Indonesia: A gendered perspective from West Kalimantan on JSTOR* (CIFOR Occasional Paper No. 124). Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/005579

Lorenzen, K. (2021). Sugarcane industry expansion and changing rural labour regimes in Mato Grosso do Sul (2000-2016). *Bioeconomy and Global Inequalities: Socio-Ecological Perspectives on Biomass Sourcing and Production*, 217–238. https://doi.org/10.1007/978-3-030-68944-5_11/FIGURES/2

Meijaard, E., & Sheil, D. (2019). The Moral Minefield of Ethical Oil Palm and Sustainable Development. *Frontiers in Forests and Global Change*, *2*, 22. https://doi.org/10.3389/FFGC.2019.00022/BIBTEX

Montilla Fernández, L. T. (2017). *Large-Scale Land Investments in Least Developed Countries*. Springer International Publishing. https://doi.org/10.1007/978-3-319-65280-1

Negatu, B., Kromhout, H., Mekonnen, Y., & Vermeulen, R. (2016). Use of Chemical Pesticides in Ethiopia: A Cross-Sectional Comparative Study on Knowledge, Attitude and Practice of

Farmers and Farm Workers in Three Farming Systems. *The Annals of Occupational Hygiene*, *60*(5), 551–566. https://doi.org/10.1093/annhyg/mew004

Oehm, F. (2015). Land Grabbing in Cambodia as a Crime Against Humanity – Approaches in International Criminal Law. *Law and Politics in Africa, Asia and Latin America*, *48*(4), 469–490.

Pacheco, P., Gnych, S., Dermawan, A., Komarudin, H., & Okarda, B. (2017). *The palm oil global value chain: Implications for economic growth and social and environmental sustainability* (Working Paper No. 220). Center for International Forestry Research (CIFOR). https://doi.org/10.17528/CIFOR/006405

Paha, J., Sautter, T., & Schumacher, R. (2021). Some Effects of EU Sugar Reforms on Development in Africa. *Intereconomics*, *56*(5), 288–294. https://doi.org/10.1007/S10272-021-1001-X

Pendrill, F., Gardner, T. A., Meyfroidt, P., Persson, U. M., Adams, J., Azevedo, T., Lima, M. G. B., Baumann, M., Curtis, P. G., Sy, V. D., Garrett, R. D., Godar, J., Goldman, E. D., Hansen, M. C., Heilmayr, R., Herold, M., Kuemmerle, T., Lathuillière, M. J., Ribeiro, V., . . . West, C [Chris] (2022). Disentangling the numbers behind agriculture-driven tropical deforestation. *Science*, *377*(6611). https://doi.org/10.1126/SCIENCE.ABM9267/SUPPL_FILE/SCIENCE.ABM9267_SM.PDF

Pendrill, F., Persson, U. M., Godar, J., Kastner, T., Moran, D., Schmidt, S., & Wood, R. (2019). Agricultural and forestry trade drives large share of tropical deforestation emissions. *Global Environmental Change*, *56*, 1–10. https://doi.org/10.1016/J.GLOENVCHA.2019.03.002

Pinizzottoa, S., Kadir, K., Gitz, V., Beuve, J. S., Nair, L., Gohet, E., Penot, E., & Meybeck, A. (2021). *Natural rubber and climate change: a policy paper* (FTA Brief No. 6). Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/008375

Pirker, J., Mosnier, A., Kraxner, F., Havlík, P., & Obersteiner, M. (2016). What are the limits to oil palm expansion? *Global Environmental Change*, *40*, 73–81. https://doi.org/10.1016/J.GLOENVCHA.2016.06.007

Pyay, S., Thanungkano, W., Mungkalasiri, J., & Musikavong, C. (2019). A life cycle assessment of intermediate rubber products in Thailand from the product environmental footprint perspective. *Journal of Cleaner Production*, *237*, 117632. https://doi.org/10.1016/J.JCLEPRO.2019.117632

RSPO. (2022). *Impact Report 2022*. https://rspo.org/our-impact/

RSPO. (2023). *Supply chains - Roundtable on Sustainable Palm Oil (RSPO)*. https://rspo.org/as-an-organisation/certification/supply-chains/

Rudloff, B. (2022). *Sustainable international value chains: The EU's new due diligence approach as part of a policy mix.* Stiftung Wissenschaft und Politik. https://www.swpberlin.org/publications/products/arbeitspapiere/Rudloff_The_EUs_new_due_diligence_approach_as_part_of_a_policy_mix_WP.pdf

Salehi, M., Cornish, K., Bahmankar, M., & Naghavi, M. R. (2021). Natural rubber-producing sources, systems, and perspectives for breeding and biotechnology studies of Taraxacum kok-saghyz. *Industrial Crops and Products*, *170*, 113667. https://doi.org/10.1016/J.INDCROP.2021.113667

Schilling-Vacaflor, A., & Gustafsson, M. T. (2023). Towards more sustainable global supply chains? Company compliance with new human rights and environmental due diligence laws. *Environmental Politics*, 1–22. https://doi.org/10.1080/09644016.2023.2221983/SUPPL_FILE/FENP_A_2221983_SM4875.DOCX

Schilling-Vacaflor, A., & Lenschow, A. (2021). Hardening foreign corporate accountability through mandatory due diligence in the European Union? New trends and persisting challenges. *Regulation & Governance*, *17*(3), 677–693. https://doi.org/10.1111/REGO.12402

Schleicher, T., Hilbert, I., Manhart, A., Hennenberg, K., Ernah, Vidya, S., & Fakhriya, I. (2019). *Production of Palm Oil in Indonesia*. https://www.oeko.de/fileadmin/oekodoc/BioMacht-palm-oil-report.pdf

Shahab, N. (2016). *Indonesia: One Map Policy Overlapping Land Claims and Conflicts*. http://fwi.or.id/publikasi/potret-keadaan-hutan-indonesia-

Sinar Mas Agro Resources and Technology Tbk. (2023). *Palm Supply Chain Traceability & Transformation - PT Sinar Mas Agro Resources and Technology Tbk*. https://www.smart-tbk.com/en/berkelanjutan/pengadaan-yang-bertanggung-jawab/kemamputelusuran-transformasi-rantai-pasok/

Steinweg, T., Drennen, Z., Advisers, C., & Rijk, G. (2017). *Unsustainable Palm Oil Faces Increasing Market Access Risks: NDPE Sourcing Policies Cover 74 Percent of Southeast Asia's Refining Capacity (Updated Version)*. https://chainreactionresearch.com/wp-content/uploads/2017/11/unsustainable-palm-oil-faces-increasing-market-access-risks-final-1_updated-july-2018.pdf

Swinnen, J. (2016). Economics and politics of food standards, trade, and development. *Agricultural Economics*, *47*(S1), 7–19. https://doi.org/10.1111/AGEC.12316

Teixeira, F., & Sherfinski, D. (2021). *Ethanol: Brazil's sugar-based biofuel built on labor abuse | Context*. *Thomson Reuters Foundation*. https://www.context.news/money-power-people/long-read/ethanol-brazils-sugar-based-biofuel-built-on-labor-abuse

ten Kate, A., Kuepper, B., & Piotrowski, M. (2020). *NDPE Policies Cover 83% of Palm Oil Refineries; Implementation at 78%*. https://chainreactionresearch.com/wp-content/uploads/2020/04/NDPE-Policies-Cover-83-of-Palm-Oil-Refining-Market.pdf

Trase. (2020). *Trase Insights - Yearbook 2020 - Major steps towards sector-wide traceability*. https://insights.trase.earth/yearbook/contexts/indonesian_palm_oil/

Trase. (2023). *Trase*. https://www.trase.earth/

Voora, V., Bermúdez, S., & Larrea, C. (2020). *Global Market Report: Sugar*. https://www.iisd.org/system/files/publications/ssi-global-market-report-sugar.pdf

Warren-Thomas, E., Ahrends, A., Wang, Y., Wang, M. M. H., & Jones, J. P. G. (2023). Rubber's inclusion in zero-deforestation legislation is necessary but not sufficient to reduce impacts on biodiversity. *Conservation Letters*, e12967. https://doi.org/10.1111/CONL.12967

Warren-Thomas, E., Edwards, D. P., Bebber, D. P., Chhang, P., Diment, A. N., Evans, T. D., Lambrick, F. H., Maxwell, J. F., Nut, M., O'Kelly, H. J., Theilade, I., & Dolman, P. M. (2018). Protecting tropical forests from the rapid expansion of rubber using carbon payments. *Nature Communications*, *9*(1), 1–12. https://doi.org/10.1038/s41467-018-03287-9

World Rainforest Movement. (2019). *Mekong: Rubber Fever Strikes Again*. *WRM Bulletin 245*. https://www.wrm.org.uy/bulletin-articles/mekong-rubber-fever-strikes-again

Zamfir, I. (2020). *Towards a mandatory EU system of due diligence for supply chains*. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2020)659299

Zheng, Y., Ana Cláudia Dos Santos Luciano, Dong, J., & Yuan, W. (2022). High-resolution map of sugarcane cultivation in Brazil using a phenology-based method. *Earth System Science Data*, *14*(4), 2065–2080. https://doi.org/10.5194/ESSD-14-2065-2022

Zu Ermgassen, E. K. H. J., Lima, M. G. B., Bellfield, H., Dontenville, A., Gardner, T. A., Godar, J., Heilmayr, R., Indenbaum, R., Reis, T. N. P. d., Ribeiro, V., Abu, I. O., Szantoi, Z., & Meyfroidt, P. (2022). Addressing indirect sourcing in zero deforestation commodity supply chains. *Science Advances*, *8*(17), 3132. https://doi.org/10.1126/SCIADV.ABN3132/SUPPL_FILE/SCIADV.ABN3132_SM.PDF